CLAIMS

1. An apparatus for investigating the wall of a borehole filled with non-conductive mud, said apparatus comprising:

5   - a pad having an inside face and an outside face for pressing against the wall of the borehole;

   - a set of measurement electrodes mounted on the outside face of the pad, potentials differences being measured between said measurement electrodes in order to provide measured points representative of the resistivity of the

10   formation;

   - both a source electrode and a return electrode adapted to inject current into the formation, the set of measurement electrodes being situated between the source electrode and the return electrode;

   characterized in that the set of measurement electrodes comprises two substantially

15   horizontal rows of electrodes, said two rows being horizontally offset from each other, such that the potentials differences measured between said measurement electrodes are representative of both the vertical component and the horizontal component of the total electric field in the formation at each measured point.

2. The apparatus according to claim 1, wherein each measured point is situated at

20   the midpoint of the vertical median line of a triangle constituted by an elementary group of three measurement electrodes among which two of them are from the same row and one of them is from the other row of measurement electrodes.

3. The apparatus according to claim 1, wherein each the measured point is situated at the position of each measurement electrode.

25 4. The apparatus according to claim 1, wherein each measured point faces each measurement electrode and is vertically offset from said measurement electrode by one half of the vertical offset between said two rows.

5. The apparatus according claim 1, wherein the measured points are situated at the midpoints of each of the lines joining the measurement electrodes of one row with the adjacent electrodes of the other row.

6. The apparatus according to any preceding claim, wherein the pad is made out of non-conductive material.

7. The apparatus according to any one of claim 1 to 5, wherein the pad further comprises shielding means which are arranged between the source electrode and the measurement electrodes and between the measurement electrodes and the return electrode, said shielding means being flush with or almost flush with the outside face of the pad.

8. The apparatus according to claim 7, wherein the pad itself constitutes the shielding means, said pad being made of electrically conductive material

9. The apparatus according to any preceding claim, further comprising voltage-measuring means coupled to said set of measurement electrodes for measuring said potential differences between said measurement electrodes.

10. The apparatus according to claim 9, further comprising signal processing means coupled to said set of measurement electrodes for generating a resistivity image of the borehole wall based on potential differences measured by said voltage measuring means.

11. The apparatus according to claim 10, wherein each measured point constitutes a pixel of the resistivity image of the borehole wall.

12. The apparatus according to any preceding claim, wherein the vertical offset and the horizontal offset between said two rows of measurement electrodes are substantially of a fifth of an inch.

13. Method for investigating the wall of a borehole in a geological formation wherein a borehole filled with non-conductive mud passes, the method comprising:

    -   pressing a pad against the borehole wall, said pad comprising a current electrode and a return electrode;

- generating a current to flow into the formation via said current electrode and said return electrode between which a potential is applied;

- measuring potential differences between measurement electrodes that are situated on the outside face of the pad between the current electrode and the return electrode;

- providing from said potential differences a set of measured points that are representative of the resistivity of the borehole wall;

said method further comprising:

- arranging said measurement electrodes in two rows that are substantially horizontal and horizontally offset from each other;

- deducing from said potentials differences the vertical component and the horizontal component of the electric field in the formation at each measured point;

- summing said vertical and horizontal components in order to provide the total electric field in the formation at each measured point.

14. The method according to claim 13, wherein each measured point is situated at the midpoint of the vertical median line of a triangle constituted by an elementary group of three adjacent measurement electrodes among which two of them are from the same row and one of them is from the other row of measurement electrodes.

15. The method according to claim 14, further comprising:

- calculating the horizontal and vertical components of the electric field generated in each elementary group of three adjacent measurement electrodes;

- depth shifting the horizontal component of said electric field to the level of the vertical component;

- summing the said two components vectorially in order to obtain the total electric field in each of said group of three adjacent measurement electrodes.

16. The method according to claim 15, wherein the vertical component of the electric field is measured at the midpoint of the vertical median line of the triangle formed by the elementary group of three adjacent measurement electrodes.

17. The method according to claim 16, wherein the vertical component of the total electric field is given by:

$E_{yi} = dVy_i = (V_{i-1} + V_{i+1})/2 - V_i = (\delta V_{i+1} + \delta V_i)/2$ where dVy is the computed vertical potential difference, V_i etc. are the potentials at each measurement electrodes, and δV_i and δV_{i+1} are the measured potential differences between said adjacent measurement electrodes.

18. The method according to any one of claim 15 to 17 wherein the horizontal component of the electric field is measured at the center of the horizontal side of the triangle constituted by the elementary group of three adjacent measurement electrodes.

19. The method according to claim 18, wherein the horizontal component of the total electric field is given by:

$E_{xi} = dVx_i / dx$ where dVx_i is the computed potential difference in the horizontal direction and is given by $dVx_i = V_{i+1} - V_{i-1} = \delta V_{i+1} - \delta V_i$, where V_i etc. are the potentials at each measurement electrodes, and δV_i and δV_{i+1} are the measured potential differences between said adjacent measurement electrodes.

20. The method according to claim 13, further comprising:

- measuring the measurement electrodes potentials of the two rows relative to a reference for a first measurement depth d;

- repeating the measurement of the measurement electrodes potentials for the two rows at a second and at a third measurement depths, said second and third depths being respectively spaced from the first measurement depth by d+dy and d-dy , wherein dy corresponds to the vertical offset between the two rows of the measurement electrodes,

- combining said electrodes potentials at the three depths of measurement in order to provide a virtual set of measurement electrodes wherein each electrode of the first row faces an electrode of the second row;and

- measuring potentials differences between electrodes of said virtual set of measurement electrodes in order to provide the set of measured points.

21. The method according to claim 13, wherein the measured points are situated at the midpoints of each of the lines joining the measurement electrodes of one row with the adjacent electrodes of the other row.

22. The method according to claim 21, further comprising:

- measuring the potential differences between a first pair of adjacent measurement electrodes and a second pair of adjacent electrodes, wherein all of said measurement electrodes are distinct ones and each pair is constituted by a measurement electrode from one row and a measurement electrode from the other row;

- interpolating said two potential differences in order to obtain a third calculated potential difference which is calculated between a pair of virtual adjacent measurement electrodes that are each situated at the midpoint of the lines joining electrodes from the first and second pairs that are situated on the same row.

23. The method according to claim 22, wherein the horizontal and vertical components of the total electric field are respectively given by:

$Ex_i = (\delta V_i - \delta U_i) / dx$, and

$Ey_i = (\delta V_i + \delta U_i) / 2dy$

where $\delta V_i = D (\cos\varphi\, Ex_i + \sin\varphi\, Ey_i) = Ex_i\, dx/2 + Ey_i\, dy$,and

$\delta U_i = D (-\cos\varphi\, Ex_i + \sin\varphi\, Ey_i) = Ey_i\, dy - Ex_i\, dx/2$

where D is the diagonal distance between adjacent measurement electrodes of different row, dy and dx are respectively the vertical and horizontal offsets between the two rows of measurement electrodes and φ is the direction of the measurement of the potential differences between adjacent measurement electrodes.

24. The method according to any one of claim 13 to 23, further comprising:

- generating a resistivity image of the borehole wall based on the total electric field at each of the measured point, said measured points constituting pixels of said image.

5   25. The method according to claim 24, further comprising:

- determining the position and the orientation of the bed boundaries in the formation from said resistivity image of the borehole wall.